

**BY ORDER OF THE COMMANDER
AIR FORCE MATERIEL COMMAND**



AFMC MANUAL 24-1

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Transportation

**AUTOMOTIVE ENGINE OIL ANALYSIS
PROGRAM**

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This AFMC manual implements AFPD 24-3, *Operation, Maintenance, and Use of Transportation Vehicles and Equipment* and adds to procedures in AFMAN 24-307, *Procedures for Vehicle Maintenance Management*. It provides guidance and procedures to vehicle maintenance managers on extending engine oil and filter change intervals through oil analysis. Used engine oil comprises the bulk of waste products emanating from a vehicle maintenance flight. It is strongly recommended maintenance managers become well acquainted with all information presented herein before implementing their oil analysis program. Deviations from procedures described in this manual are prohibited without written approval from HQ AFMC/LGTV. This manual does not apply to Air National Guard or US Air Force Reserve units and members.

Chapter 1

BACKGROUND

1.1. Overview . Oil analysis is an analytical approach for monitoring oil contamination and preventing unnecessary oil changes by determining oil changes based on the oil's actual condition. Recent advances in low cost in-house oil analysis equipment allow reliable analysis within the vehicle maintenance unit. Additionally, high-density by-pass filtration is available to extend the oil's useful life as well as extending the life expectancy of the equipment. This program provides guidance on incorporating oil analysis and the use of by-pass filters into a unit level vehicle maintenance operation. Oil analysis reduces waste oil generation, purchase of new motor oil, labor hours for waste oil management, and risks involved with the storage, pumping, and shipment of waste oil. While oil analysis can provide the added benefit of early indication of internal engine wear, engine wear analysis is not the intent of this program and should not be used as a sole determinate in making repair decisions. Moving from time and or mileage to analysis based oil change intervals, along with the use of by-pass filtration to extend oil drain intervals, is a demanding and challenging endeavor. However, after the implementation of this program, maintenance man-hours required to maintain the lubrication systems of fleets should be reduced. When considering the implementation of the oil analysis program, units have the option to consider only a portion of their fleets. Consideration should be given to targeting high value, heavy equipment with large oil sumps, which produce large quantities of waste oil. Additionally, one should focus the application of by-pass filters on their high to medium use vehicles. Due to low annual mileage or hours, low use vehicles may not be cost effective to retrofit with by-pass filters. Success of the program relies heavily on wing leadership and community support.

1.2. About Oil. Oil performs four functions in an engine, cooling, cleaning, lubrication and sealing. Oil is made up of about 75% base stock and about 25% additives. Refiners blend in various additives to prevent contaminants such as, acids, water, soot and carbon particles from forming inside the engine. Additives begin to deplete as oil is used, and eventually stop performing the function they were designed for. Contaminants will then accelerate engine wear. Changing oil removes contamination and replenishes the sump with additive rich lubricant.

1.3. Analyzers. Vehicle maintenance units must use analyzers recommended by the Management Equipment Evaluation Program (MEEP). A list of MEEP recommended equipment is provided in attachment 1. A commercial oil analysis laboratory may be used in lieu of in-house analysis when practical. If a commercial laboratory is utilized, ensure that the laboratories test oil to the following specifications: Full spectrographic analysis of 6 wear metals, silicon, and 13 additives. Also, physical tests should include viscosity, SAE grade, Fuel Soot, Water, Fuel Dilution, Antifreeze and Total Base Number.

1.4. By-Pass Filters . By-pass filters are not required to run an oil analysis program. However, their use will significantly extend oil drain intervals for most vehicles. A by-pass oil filtration system is one which provides high-density, slow filtration (one to six quarts per minute at engine operating temperature) of engine oil without affecting the primary Original Equipment Manufacturers (OEM) filtration system, removes solid contaminants down to three microns (one micron measures 1/39 millionth of an inch), controls moisture content in oil, is compatible with all MIL-SPEC oils, and must specifically claim to extend oil drain intervals. Vehicle maintenance units will use only MEEP recommended by-pass oil filtration systems. (See Atch 1) It may not be feasible to install by-pass filters on all vehicles in a fleet due to the

climate in which the vehicle is used, duration of engine run time at operating temperature, and age of the vehicle. In typically warm weather climates (where 15W40 can be used year round) all vehicles benefit from the additional filtration because flow through the filter starts almost immediately. However, in colder climates engines must run at normal operating temperature for at least ten minutes to reduce the oil's viscosity for flow through the by-pass filter. Longer run times are necessary in extremely cold climates. Managers also need to consider a vehicle's age when determining whether to install a by-pass filter. Vehicles in replacement codes "A" through "J" typically will not remain in service long enough to justify the expense of a by-pass filter.

1.5. Oil Sampling . Method, equipment, and personnel used to collect oil samples are critical aspects of the analysis program. Oil temperature, location on the engine where the sample is obtained, cleanliness of sampling equipment, amount taken, the procedure itself, and the weather are major factors in determining the accuracy of the analysis process. Improper sampling techniques will skew analysis results causing unnecessary oil changes. Purity of crankcase oil is an absolute necessity if oil analysis is to be successful. Using only one type of engine oil throughout the fleet (15W40, MIL-SPEC 2104D, meets most vehicle manufacturer requirements for lubrication) is an excellent means of ensuring purity of crankcase oil. Other methods to ensure purity of crankcase oil include placing tags on oil filler caps identifying the type of oil in use, and establishing an aggressive education campaign to inform operators the importance of using the correct engine oil. Generally, there are two methods in obtaining an engine oil sample, either by installing a petcock to an oil pressure port or by using a suction device through an access port (dip stick or filler tube). If using a suction tube to sample from the sump, do not let it touch the bottom. Also, always take the sample when the oil is hot.

1.6. Oil Analysis Interval. Analysis works best when intervals are based on the following three criteria; fuel consumption, established scheduled maintenance interval, and/or every six months. Used in concert, these three interval criteria provide the most accurate, least laborious, and safest method of ensuring the oil's contamination does not reach an unsafe level.

1.6.1. Fuel consumption is the most effective means in determining when to analyze engine oil. This criteria tracks engine use regardless of vehicle use. Oil analysis must be accomplished every 300 gallons of fuel used for diesel and gasoline engines. This indicator was established to simplify the tracking process. It employs a sufficient margin of safety ensuring both types of engines receive adequate analysis before high levels of contamination accumulate in the oil. However, accurate fuel accounting by individual vehicle is essential to ensure adequate analysis of each vehicle's engine oil. Attachment 2 provides instruction and guidance in obtaining the oil analysis fuel retrieval program. Another benefit to fuel monitoring, not connected with the analysis program, is vehicle utilization. Fuel use reflects vehicle usage, regardless of mileage or hours accumulated.

1.6.2. The scheduled maintenance interval is a convenient backup to the fuel consumption interval. Because the vehicle is already in the shop for maintenance, it is easy to ensure the oil is in satisfactory condition.

1.6.3. Our second backup to the fuel consumption interval is the six-month interval. If the vehicle's oil has not been analyzed during the previous six months, as a result of fuel or scheduled maintenance, then the oil is analyzed to ensure it is in satisfactory condition. This becomes especially important in the second and out year use of the oil.

1.7. Program Support . Wing leadership support is a key element in getting the program off the ground and maintaining its integrity. It requires the cooperation of all vehicle users and vehicle maintenance to be credible and successful.

1.8. Instructions . Vehicle Maintenance Managers must develop a Maintenance Operating Instruction detailing the operation of their oil analysis program to ensure continuity and standardization. (See Atch 3) We recommend locating the analysis equipment in the Customer Support Center. At this location, the oil is analyzed while the vehicle is being processed for maintenance and any required servicing of engine oil is documented on the work order prior to its transfer to the repair shop, streamlining the maintenance process.

1.9. Servicing Engine Oil. Operator servicing of the engine oil presents the greatest potential for crank-case contamination. Local managers must be aggressive in their efforts to minimize all possibilities of engine oil contamination. One method to help prevent accidental contamination of engine oil is by placing oil identification tags on engine oil filler caps identifying the type of oil to use. The best approach, although it may require extra manpower and addition O&M cost, is to implement procedures whereas vehicles are brought to the maintenance facility when oil levels need to be topped off.

1.10. OLVIMS. The program's data collection and analysis scheduling relies significantly on several OLVIMS systems codes to be effective. Once the program is initiated, all engine oil changes must be documented on the work order using system code 01HV. Oil analysis is documented using a new OLVIMS system code 01HX. This is needed for accurate tracking of intervals. By-pass filter installations are documented using OLVIMS system code 01HM with 01HL used to record by-pass filter element replacements.

1.11. Vehicle Warranty. Failure to change engine oil at manufacture's recommended intervals will not void warranties. Manufacturer's base lubrication warranty obligations on the oil's condition, not length of time used. Parameters established in this program are conservative in nature to ensure the oil is changed before it degrades (breaks down or becomes contaminated) to the degree it would void a manufacturer's warranty.

Chapter 2

OIL ANALYSIS PROGRAM

2.1. Insight. The first priority when accomplishing any major change in procedure is to start without a backlog. The best method to implement this program is to establish a cross-functional Process Action Team (PAT) to manage and oversee its implementation. Recommend members of the PAT be comprised of representatives from base units serviced by the vehicle maintenance flight. The outside organizations represent your customer's concerns and will assist in getting buy-in from these units.

2.2. Initial Actions .

2.2.1. Determine equipment to be used. Sampling bottles can be obtained using NSN 6640-00-165-5778. The use of by-pass filters is not mandatory with this program. If by-pass filters are installed, adherence to manufacturer's guidance on filter size and installation procedures is essential to obtain maximum benefit from these devices. (See Atch 1)

2.2.2. Brief wing leadership and gain their support. Brief the program at VCO/VCNCO meetings. Explain the benefits of the program and ensure there is an understanding of the need for accurate fuel accountability for each vehicle and proper servicing of engine oil by vehicle users.

2.2.3. Establish funding requirements. The analysis equipment and by-pass filters may qualify for Pollution Prevention Program (PPP) funding for their initial purchase. Total funding for an average size fleet (650 vehicles) can run as high as \$250K depending on the number of analyzers and by-pass filters purchased. However, it is recommended that careful consideration be given to the number of vehicles and equipment to retrofit with by-pass filters. It is recommended that the initial application of by-pass filters be directed towards high value, heavy equipment with large oil sumps, which produce large quantities of waste oil. Additionally, one should focus the application of by-filters on their High to Medium use vehicles. In most cases, low use vehicles with small sumps will not be cost effective to retrofit due to low annual mileage or hours. With this equipment under the oil analysis program, oil drains would be performed at approximately every 6,000 miles or every two to three years and saving and waste oil reduction would be realized on this equipment without the use of a by-pass filter. Phasing the purchase of equipment over several fiscal years will make it easier for wing leadership to include the program in their annual PPP funding bogie. Ensure analyzers planned for purchase are programmed in the first year's funding for the oil analysis program. Extending the purchase process prevents overwhelming the maintenance shop with filter installations.

2.2.4. Another important step, which must not be overlooked, is informing the base populous and gaining their support. Program effectiveness and accuracy will diminish without the support of the vehicle user, regardless of how efficiently the analysis program operates. Articles in local papers and daily bulletins, briefing first level supervisors and workers at their staff meetings, and one-on-one discussions with vehicle users are effective methods of getting the word out about the program. Start your information campaign well in advance of starting the analysis program. This allows the analysis concept to take root and provides a practice period for users to become familiar with the new requirements (fuel accountability, servicing of engine oil, etc.).

2.2.5. Training. When formal training is required, manufacturers of oil analyzers often provide necessary training at no cost to equipment purchasers. Try to schedule training so the analyzers are on station when training is complete, allowing trained personnel to practice their newly acquired skills.

2.3. Startup

2.3.1. Analyzer. The analyzer must be properly configured before oil analysis can begin. Follow the manufacturer's procedures for set up and start up of analyzer.

2.3.2. Starting the analysis process can be accomplished through gradual application or immediate application. Both have benefits and drawbacks and the one used will depend on the circumstances surrounding your maintenance organization. Although both processes are workable, we recommend using the "Gradual Application".

2.3.2.1. Gradual Application. Is the process of moving the fleet to analysis based intervals gradually over a period of approximately one year. Benefits include less disruption of the maintenance environment and little or no overtime. Disadvantages include delayed realization of return on investment and non-standard oil change interval criteria during the phase-in period. Procedures for gradual application are as follows:

2.3.2.1.1. When vehicles reach their scheduled maintenance interval, analyze a sample of the oil to determine condition. Change the oil and OEM filter based on analysis results. Regardless whether the oil is changed or not, change the OEM filter if an annual inspection is being accomplished in conjunction with the scheduled inspection. Use OLVIMS system code 01HX on an "F" prefix work order to record oil analysis. Analysis can be documented on the scheduled maintenance work order.

If you plan to install a by-pass filter and it is available, install it now.

2.3.2.2. Immediate Application. As the name implies, the entire fleet moves to analysis based intervals at one time. The benefits include a quicker payback on investment and standardization of maintenance procedures. Disadvantages include significant disruption of the maintenance workload until the process becomes routine. The following paragraphs describe procedures for immediate application of an oil analysis program.

2.3.2.2.1. Retrieve from OLVIMS all fuel consumption and last scheduled maintenance data from the previous twelve months for all vehicles. Starting from the most recent scheduled maintenance where the oil was changed, calculate each vehicle's fuel consumption.

2.3.2.2.2. All vehicles with fuel consumption exceeding 300 gallons since the last oil change must have their oil analyzed immediately to determine condition. Change the oil and OEM filter based on analysis results. Use OLVIMS system code "01HX" on an "F" prefix work order to record oil analysis.

2.3.2.2.3. Based on the date of the last oil change, calculate the number of days elapsed. Immediately analyze the oil on all vehicles that have not had an oil change in the last 180 days and are not due analysis as a result of fuel consumption. Record the analysis results in the same manner as described in paragraph 2.3.2.2.2. Use OLVIMS system code "01HX" on an "F" prefix work order to record oil analysis.

2.3.2.2.4. Schedule vehicles for maintenance when by-pass filters are available for installation.

2.4. Running the Program

2.4.1. As the program moves into the operational phase, vigilance in fuel consumption tracking, oil replenishment, analysis

procedures, and oil sampling techniques all take on a heightened level of importance as these factors drive the accuracy of the entire oil analysis program.

2.4.1.1. Fuel consumption is tracked by computing the amount of fuel charged to the vehicle starting from the date of the last oil analysis action (system code 01HX) to the present day (fuel retrieval program at attachment 2). The source of this data originates from the Materiel Transaction Listing (D22), which provides a record of fuel consumption. When the vehicle's fuel consumption exceeds 300 gallons since the last oil analysis, an oil sample must be obtained and analyzed to determine its condition. Vehicle maintenance organizations must calculate fuel consumption weekly to effectively monitor each vehicle's oil condition.

2.4.1.2. Analyze the oil in each vehicle every 300 gallons of fuel used, during all scheduled maintenance actions (OLVIMS System code 34AA), and if the oil has not been analyzed within the past six months as a result of fuel use or scheduled maintenance. The oil analysis fuel retrieval program will also identify vehicles meeting the six-month interval criteria.

2.4.1.3. Original equipment oil filters must be changed when oil is replaced and during the vehicles' annual inspection. The original equipment filter must not be allowed to remain on the vehicle longer than one year. These filters are not intended for extended use.

2.4.1.4. Use OLVIMS system code 01HX on vehicle work orders to document oil analysis. Use 01HL when analysis dictates changing only the by-pass filter element. Use OLVIMS system code 01HV when changing the engine oil.

2.4.2. When preparing vehicles for TDY, change the engine oil, all OEM oil filters, and all by-pass filter elements prior to shipment. By-pass filters will remain on the vehicle and be documented as such in the remark section of the out going LTI. Vehicles returning from TDY will have the oil changed and all by-pass and OEM filter elements replaced prior to being released from vehicle maintenance.

2.4.3. Vehicles approved for salvage must have any by-pass filter assemblies and accessories removed from the vehicle prior to transfer to DRMO. Be sure to cap all oil ports left open. Attach a serviceable tag to the by-pass filter assembly and store as work order residue until reinstalled on another vehicle.

2.4.4. Vehicle transfers: Vehicles being permanently transferred to another installation will have the oil and all OEM filters changed and any installed by-pass filter assemblies removed. Cap all oil ports left open. Attach a serviceable tag to the by-pass filter assembly and store as work order residue until reinstalled on another vehicle.

STANLEY A. SIEG, Brigadier General, USAF
Director of Logistics

Attachment 1**OIL ANALYSIS EQUIPMENT REFERENCE**

1. The following is provided to assist vehicle maintenance flights in purchasing their Computational Systems Incorporated (CSI) oil analyzer.

- a. CSI (5100 OilView and 51DV analyzers)
 - NSN: 6650-01-408-3269
- b. Lubri Sensor (Model 126 portable analyzer, includes the Lubri Sensor and Hydroil sensor)
 - NSN: 6630-01-420-9948

2. The following is a list of accepted by-pass filters supporting this program.

- a. ENVIRO FILTRATION
 - Phone: 1-219-884-7963
 - One filter element services all size systems by stacking the appropriate number of elements.
- b. GULF COAST FILTERS
 - Phone: 1-800-398-8114 or 228-832-1663
 - Filter elements use off-the-shelf toilet and paper towel rolls.
- c. OIL GUARD
 - Phone: 1-800-861-7061
 - Spin-on cotton/cellulose element.
- d. T.F. PURIFINER
 - Phone: 1-407-547-4025
 - Electric heating element converts water content and fuel dilution to vapor which is vented to the air filter.

Attachment 2

OIL ANALYSIS FUEL RETRIEVAL PROGRAM

The following provides guidance in obtaining and installing the oil analysis fuel retrieval program.

You may access the Internet to download the OVRDUOIL.ZIP file at HQ AFMC/LGT/LGTV homepage.

From this page select the OLVIMS section.

b. Select the OVRDUOIL.ZIP file and copy to your C:\TEMP directory.

You are now ready to use PKUNZIP to uncompress this file and send it to the C:\OLVIMS\SYSTEM directory.

Go to your C:\TEMP directory.

Type PKUNZIP OVRDUOIL.ZIP C:\OLVIMS\SYSTEM. This will uncompress the file and send it to the systems directory.

You are now ready to run the program. Note that it must be run from the MSDOS prompt.

From the C:> type CD\OLVIMS\SYSTEM and press enter.

Type NVQEXE NVQTOL? (? = Site Code) and press enter.

The program will look for vehicles that have used 300 gallons of fuel and create a list of vehicles due for inspection.

Attachment 3**SAMPLE MAINTENANCE OPERATING INSTRUCTION****DEPARTMENT OF THE AIR FORCE****LGTM OI 24-XX**

(XXXX) Transportation Squadron

Vehicle Maintenance Flight

Anywhere AFB, USA 12345

(Date)

Motor Vehicles

OIL ANALYSIS PROGRAM (OAP)

PURPOSE AND SCOPE: This instruction establishes responsibilities, methods and procedures for the operation and maintenance of an oil analysis program within this vehicle maintenance flight. Oil analysis is an analytical approach in determining contamination of automotive engine oil. Use of analysis and by-pass filters significantly reduces this flight's generation of waste oil and the purchase of new oil. This instruction applies to all personnel assigned to the vehicle maintenance flight. Deviations from procedure herein are prohibited without prior approval from the VMM.

1. RESPONSIBILITIES:

a. The Vehicle Maintenance Manager has overall responsibility for policy, procedure, and management of the OAP.

b. The NCOIC of Customer Service Center (CSC) is responsible for the daily operation and maintenance of the OAP within vehicle maintenance. This includes but is not limited to the following:

(1) Initiate and enforce all policy and procedures set forth by the vehicle maintenance manager on the operation and maintenance of the oil analysis program.

(2) Ensure the security and serviceability of all equipment used in the OAP.

(3) Ensure all OAP equipment is operated IAW manufacturer's specifications.

(4) Ensure all personnel assigned to perform oil analysis functions are fully trained in proper oil analysis procedures, operation of analysis equipment, and maintenance of equipment.

(5) Develop lesson plans to standardize training in oil analysis procedures.

(6) Develop and maintain a continuity book to establish a record of corporate knowledge of the OAP.

c. MC&A will track the oil analysis interval using the OAP fuel retrieval program.

2. METHODS:

a. Oil Sampling: Oil samples will be taken via an installed petcock or by a suction device using the “free catch” method obtaining 75ml (three-quarters full of sample bottle NSN 6640001655778) of engine oil. If a by-pass filter is installed, the samples can be obtained by using the petcock installed on the inlet side of the by-pass filter.

b. Analysis: Accomplish all oil analysis using a MEEP approved analyzer or a local laboratory. Save analysis results.

c. Oil change interval: Analysis interval is based on the following three criteria; fuel consumption, established scheduled maintenance interval, and/or every six months. Used in concert, these three interval criteria provide the most accurate, least laborious, and safest method of ensuring the oil’s lubricity remains at an optimum level.

d. Use OLVIMS system code 01HX on an “F” prefix vehicle work order to document oil analysis. Use 01HL on work orders to document by-pass filter element replacement. Use OLVIMS system code 01HV on work orders to document changing the engine oil.

3. PROCEDURES

a. Oil sampling: All oil samples will be drawn only when the engine has been operating at manufacture’s operating temperature for at least 10 minutes. Normally, all vehicles requiring an oil sample will be brought to the shop to have the sample drawn. Only those vehicles where it would not be practical (tracked vehicles, large construction equipment, etc.) to bring them to the shop for oil sampling will have their sample drawn in the field. Personnel will make every effort to prevent spillage during the entire sampling process. Sample bottles will be marked with vehicle registration number, date sample taken, and odometer reading or hour reading. Use a new sample bottle for every oil sample drawn. Do not clean and re-use sampling bottles.

b. Analysis: Each sample bottle must be three-quarters full of oil and the oil at room temperature to ensure consistency of analysis results. Dispose of oil sample as waste oil after analysis is completed.

c. Analysis Interval: MC&A along with the NCOIC of CSC will coordinate their efforts in scheduling vehicles into the shop for analysis. MC&A will provide the NCOIC of CSC a list of vehicles needing analysis for the week. MC&A will acquire this list by running the oil analysis interval program. Additionally, MC&A will provide a separate list to each outlying work center. Each outlying work center will coordinate with the units they support to obtain the necessary oil samples. Oil samples will be brought to CSC for analysis.

(1) Analyze engine oil at 300-gallon intervals of fuel consumption for each vehicle. Fuel consumption is tracked by computing the amount of fuel charged to the vehicle starting from the date of the last oil analysis action (system code 01HX) to the present day.

(2) Analyze a vehicle's engine oil during every scheduled maintenance action (35AA).

(3) Analyze a vehicle's engine oil if it has not been analyzed in the previous six months as a result of fuel consumption or scheduled maintenance. The oil analysis fuel retrieval program will identify these vehicles.

d. Vehicles with two engines: Vehicles with two engines will always have oil from both engines analyzed simultaneously. At no time will one engine oil receive analysis without the other receiving the same analysis. No additional documentation is necessary on the vehicle work order other than the standard 01HX system code. However, the second engine analysis must be tracked separately.

e. Vehicles going TDY: When preparing vehicles for TDY, change the engine oil, all OEM oil filters, and all by-pass filter elements prior to shipment. By-pass filters will remain on the vehicle and be documented as such in the remark section of the out going LTI. Vehicles returning from TDY will have the oil changed and all by-pass and OEM filter elements replaced prior to being released from vehicle maintenance.

f. Vehicles that are transferred into the fleet from other bases will have their oil changed unless the oil type can be confirmed by contacting the previous base. If the oil type is confirmed and is the same used in our shop, then analyze the oil during the acceptance inspection and follow normal procedure based on analysis results.

g. To reduce the possibility of mixing viscosity rated oils in the same engine, engine oil 15W40 (MIL-SPEC 2104D) will be the ONLY oil used in vehicle engine crankcases for the entire fleet.

h. Vehicles being permanently transferred to another installation (RDO action) will have all by-pass filter assemblies removed, all OEM filters replaced, and the engine oil replaced prior to shipment.

- i. Vehicles approved for salvage must have all by-pass filter assemblies removed prior to transfer to DRMO.

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